



## Review

## A review of the otological aspects of whiplash injury

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## ABSTRACT

Approximately 10% of patients who have suffered with whiplash injury will develop otological symptoms such as tinnitus, deafness and vertigo. Some of these are purely subjective symptoms; nevertheless, for the majority there are specific tests that can be undertaken. These tests can quantify the extent and severity of the symptoms as well as provide guidance as to the correct rehabilitation pathway. This article reviews the body of literature relating to the otological aspects of whiplash injury and gives an overview for medical and legal professionals.

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## 1. Introduction

Crowe first described whiplash injury in 1928 at the Western Orthopaedic Association Meeting in San Francisco.<sup>1</sup> The injury had been described as a clinical entity in the First World War as an acceleration extension flexion injury to the neck related to catapult assisted take-offs from aircraft carriers.

It is perhaps surprising to think that significant injuries can occur following even low speed car collisions but simulated accidents have shown that a 5-mile an hour rear end car collision can result in a positive acceleration of 8.2 G and 4.7 G of the head and chest, respectively.<sup>2</sup> These forces explain the damage that can occur to an unsupported neck.

Literature searches suggest that balance and hearing problems occur in 5–50% of whiplash injuries. The large discrepancies in the literature regarding incidence and types of symptomatology in whiplash may be because of the evolution of whiplash injury over the years with the advent of head rests and seat belts.<sup>3</sup> Of 1,97,731 whiplash cases in Germany in 1992, about 15–20% developed the so-called late whiplash syndrome with persistent complaints including headache, vertigo, instability, nausea, tinnitus and hearing loss.<sup>4</sup>

With respect to hearing and balance problems due to whiplash, the exact nature of the lesion is not known but the following have been put forward as possible explanations: Transient ischaemia or haemorrhage in the labyrinth as a result of transient compression of the vertebral artery, direct labyrinthine concussion, brain stem concussion, the noise of the collision causing acoustic trauma or

psychological triggering of a pre-existing hearing disorder. With so many suggestions it is a cynical truism to say we do not know the exact cause and site of the lesion.

Hearing loss, tinnitus and dizziness are the main otological symptoms, which can occur related to the whiplash injury.

## 2. Deafness

It is unusual to develop hearing loss due to damage either to the eardrum or the ossicles within the middle ear without there being an associated fracture of the skull base. However, pure whiplash injury can cause several types of deafness.

Sometimes the deafness is not real, it is exaggerated or fabricated and we term this non-organic hearing loss (NOHL). On subjective testing of hearing in the form of a pure tone audiogram, the result may be a flat hearing loss in the region of 50 dB, however, there is no audiogram pattern that is consistent for all NOHL cases. Fortunately this type of hearing loss can usually be recognised by the examining clinician plus there are objective electrophysiological tests and impedance audiometry which will confirm this diagnosis and establish the true hearing thresholds.<sup>5</sup>

Most patients who following whiplash complain of hearing loss will not have had a pre-accident audiogram and not all people will have normal hearing prior to the accident, therefore doubt will sometimes be expressed as to whether the whiplash injury actually caused the hearing loss. The authors have seen a 50-year-old lady who developed a high frequency hearing loss following a whiplash injury, having seen the same lady three years previously and undertaken an audiogram that showed perfectly normal hearing at that time. The sudden hearing change after three years could not be attributed to any cause other than the whiplash.

Often, compensation claimants do have possible causes of ear disorder other than the whiplash injury they have sustained. It

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can be argued that pre-existing issues such as ageing, previous noise exposure and chronic medical conditions could account for the symptoms that are the subject of the compensation claim. However, the expert medical witness simply needs to be satisfied that there is at least a 51% chance (the balance of probability) that the claimant's symptoms are attributable to whiplash injury rather than any other cause.

Medicolegal assessment of hearing damage requires an equitable baseline against which to compare the hearing of the claimant. This baseline, or 'notional person', should match the claimant in every respect except for the cause of the hearing loss. The amount of disability attributable to the injury is the difference between the percentage disability of the claimant and that of the 'notional person'. International Standard (ISO) tables exist that provide normal hearing thresholds for any given age.<sup>6,7</sup>

High frequency hearing loss is the most common form of hearing loss associated with whiplash injury and is easily demonstrated with a pure tone audiogram. This type of hearing loss produces difficulties hearing the high frequency consonant sounds and makes it difficult for the patient to discriminate speech especially in the presence of background noise or when several people are talking. Fortunately modern hearing aids can correct this problem.

Some patients with a normal audiogram post-whiplash will complain of hearing difficulties with poor awareness of sound and poor speech discrimination. This might be considered as an exaggeration of symptoms; however, scientific studies have shown that such patients undertaking a specific test called the "speech and noise test" do not do as well as the normal population. This test is not usually undertaken in the UK but perhaps in compensation cases it should be resurrected.<sup>8–10</sup>

With regard to prognoses the hearing loss will be permanent and, depending upon patient's age, there can be further deterioration in hearing thresholds related to the normal ageing process though the trauma does not exacerbate this process.

### 3. Tinnitus

Tinnitus is Latin for ringing. By definition it is perception of sound in the absence of any corresponding external sound. Tinnitus is a very common condition and over the age of 50, 10% of the population are affected.<sup>11</sup> Sometimes the tinnitus is audible relating to rhythmical contraction of muscles or vascular abnormalities and a clinician obviously can confirm this. However, the majority of tinnitus that one sees related to whiplash is purely subjective. The origin of the tinnitus can either be otocentric i.e. that there is a co-existing abnormality of the ear itself or there may be an abnormality of the central processing of the neuronal signals, a theory attributed to Jastreboff and Hazell.<sup>12</sup>

Tinnitus may vary from pure awareness to irritation by the noise. Some people have difficulty in hearing because of the loudness of the tinnitus. A more severe form of tinnitus can cause a variety of symptoms, which are actually more in the psychological domain than in the otological domain (including tension, frustration, loss of concentration, sleep disturbance and general inability to cope with day-to-day life).

Tinnitus is not measurable objectively but on a self-assessment basis, it can be graded from 1 to 10 where 1 is barely perceptible and 10 difficult to live with. An audiological scientist can also match it in intensity and frequency.<sup>13</sup> Tinnitus for compensation purposes is categorised as either being mild, moderate or severe.

There is no medical treatment for tinnitus. There is however help that can be obtained from tinnitus re-training therapy which are basically a series of techniques and philosophies that have been borrowed from the management of chronic pain with an audiological bias.<sup>14</sup>

To say that there is no cure for tinnitus is correct but improvement often occurs with or without treatment. With the reduction in co-incidental pressures, perhaps related to the settlement of a compensation claim, a certain proportion of tinnitus symptoms will improve. However, some tinnitus causes persistent distress or disability, so that with regard to prognoses one must be very guarded about resolution of this troublesome symptom.

### 4. Vertigo

Vertigo is a sudden sensation of unsteadiness or that one's surroundings are moving.

One may feel as though one is spinning around like on a roundabout or that the inside of the head is spinning. In any event, it is an illusion of rotational movement. The sensation of balance is taken for granted but it is complicated and relies on the input of three systems. These are (1) the vestibular apparatus of the inner ear, (2) the body's proprioception sensors that tell us where our joints and limbs are located and (3) vision.

The organ of balance is located within the inner ear in the so-called vestibular labyrinth. This consists of a series of semi-circular canals, which contain fluid and fine hair cells. These detect movement of the head. In addition there is the utricle, a sac-like structure into which the semi-circular canals open which contain tiny granules of crystals of calcium carbonate which detect gravity as well as back and forth movement.

Some patients who suffer with a whiplash injury will complain of vague unsteadiness following the incident and this may not be due to any true vestibular problem but more of a problem related to the change in posture they might adopt to protect any injured neck. Some whiplash patients will describe true unsteadiness and rotational vertigo to the extent of falling over or colliding with doorframes etc. Using various clinical and diagnostic techniques it is possible to confirm the abnormality and the damage that has occurred to the vestibular mechanism.

Clinical examination may show abnormal movements of the eyes related to following a clinician's finger, (so-called nystagmus). Basic neurological tests (such as the Unterberger test and the Rombergs test where the balance is tested dynamically with the eyes closed) can indicate and confirm that there is a problem. Sophisticated techniques such as videonystagmography can define the nature and the extent of the lesion and the recently developed posturography can give even further diagnostic information.<sup>15–18</sup>

Following whiplash injuries we have seen patients develop either unilateral or bilateral vestibular damage. While one can expect for there to be some natural improvement in symptoms as the brain accommodates to the altered messages coming from each labyrinth, sometimes help is necessary. The standard techniques for rehabilitation are the Cooksey–Cawthorne exercises,<sup>19,20</sup> however with the improvements in technology such as posturography techniques one can offer more tailored management regimes.<sup>21</sup>

Following whiplash the most common type of vertigo that we see is benign paroxysmal positional vertigo (BPPV),<sup>22</sup> which is characterised by a short duration of vertigo, associated with movement of the head. For instance, looking up and to the side, turning over in bed, sometimes moving from a horizontal to a vertical position. Following trauma the crystals of calcium carbonate in the utricle become displaced and lie within the labyrinthine fluid and in certain positions will stimulate the balance nerve endings in the semi-circular canals causing brief sensations of spinning. The diagnosis is confirmed by positional tests<sup>23,24</sup> and fortunately is amenable to very simple treatment. Having determined which ear and which semi-circular canal is affected it is then possible to undertake a series of movements of the head which move the loose particles of crystal into the utricle where they will not cause stimulation of

the sensitive nerve endings in the semi-circular canals. This very simple clinic based procedure is very effective especially if the patient avoids lying flat for the next 24–48 h, and should the condition recur the procedure can then be repeated.<sup>25</sup>

BPPV therefore is usually curable. However, the prognosis for other forms of labyrinthine damage depends on the degree of compensation that occurs by the central nervous system.<sup>3,26</sup> Even so, sudden movements in the dark often produce some degree of unsteadiness.

## 5. Summary

Approximately 10% of patients who have suffered with whiplash injury will develop otological symptoms such as tinnitus, deafness and vertigo. Some of these are purely subjective symptoms, and therefore perhaps open to exaggeration. However for the majority there are specific tests, which can be undertaken to quantify the extent and severity of the symptoms, and they can also be useful in terms of advising the correct rehabilitation pathway.

## Conflict of interest statement

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